NETEX Program

Networking in Extreme Environments

Example UWB Systems

Link Budget Calculations

7 April Industry Day Workshop

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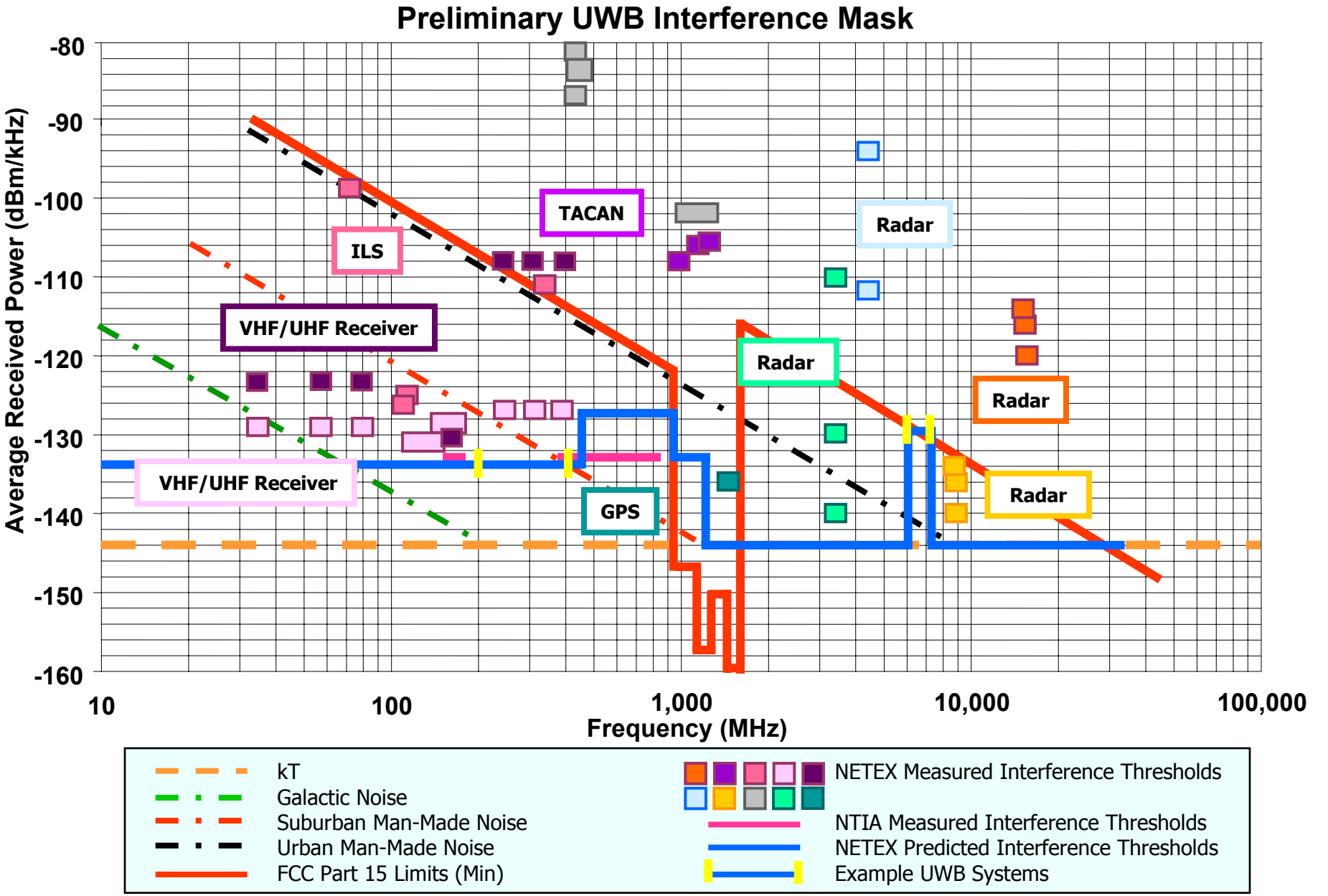
Interference Study



Operational Parameters for Example Systems

SYSTEM TYPE	HAND HELD	HIGH DATA/ SHORT RANGE	RADAR 1 m^2 TARGET	RADAR PERSONNEL 1 m^2
POWER dBm	14	10	40	50
RANGE Meters	500	100	100	100 Foliage 10% of Range*
DATA RATE	10 Kbps	10 Mbps	10 Kpps	100 pps
FREQUENCY	200 – 400 MHz	6 -7 GHz	6 – 7 GHz	700 – 1000 MHz
BANDWIDTH	200 MHz	1 GHz	1 GHz	300 MHz
SIGNAL/NOISE dB	10	7	2	6.6
INTERFERENCE/ NOISE dB	6 @20 m	-9 @10 m	- 21 @10 m	20 @10 m

One Way Foliage Loss = 0.2 F0.3 R0.6 = 0.2 (850)0.3(10)0.6
= 0.2(7.57)(3.98) = 6.0 dB Round Trip Foliage Loss = 12 dB

Link Budget and EMI Analysis

Link Budget:

$$S/N = P_T + G_T - L_T - L + G_R - L_R - P_N$$

Free Space Propagation Loss: ---- **Plane Earth Propagation Loss:**

$L = (- 28 + 20 \text{ Log } F + 20 \text{ Log } D)$ $\quad L = 40 \text{ Log } D - 20 \text{ Log } H_T H_R$

Radar

$$S/N = 17 + P_T + G_T + 10 \text{ LOG } A_T + G_R - L_S - 40 \text{ Log } R - 20 \text{ Log } F - P_N$$

Interference Analysis:

$$I/N = P_{TP} + 10\text{Log}[(DC)(BWCF)] + G_{TR} - L_T - (-28 + 20\text{Log}F + 20 \text{ Log } D) + G_{RT} - L_R - (-174 + NF + 10\text{Log}BW)$$

S/N = Signal to Noise Ratio (dB)
G_T = Gain of TX Antenna (dB)
L = Propagation Loss (dB)
L_R = System Loss at RX (dB)
F = Frequency (MHz)
H_T = Height of TX Antenna (meters)
H_R = Height of RX Antenna (meters)
P_{TP} = Peak UWB Power (dBm)
BW = RX Bandwidth (Hz)
PW = Pulse Width (Seconds)
$BWCF = 0$ for $BW > 1/PW$
$BWCF = (PRF)(PW)$ for $BW < PRF$
G_{TR} = Gain of TX Antenna in Direction of RX
A_T = Radar Cross Section (m^2)
R = Range (meters)

P_T = TX Power (dBm)
L_T = System Loss at the TX (dB)
G_R = Gain of RX Antenna (dB)
P_N = RX Input Noise (dBm)
D = Distance (meters)
P_N = Receiver Noise (dBm)
$= -174 + NF + 10 \text{ Log } BW$ (Hz)
NF = RX Noise Figure (dB)
DC = Duty Cycle = $(PW)(PRF)$
PRF = Pulse Repetition Rate (pps)
$BWCF = (BW)(PW)$ for $BW > PRF$
I/N = Interference to Noise in dB
G_{RT} = Gain of RX Antenna in Direction of TX
L_S = Total System Loss (dB)

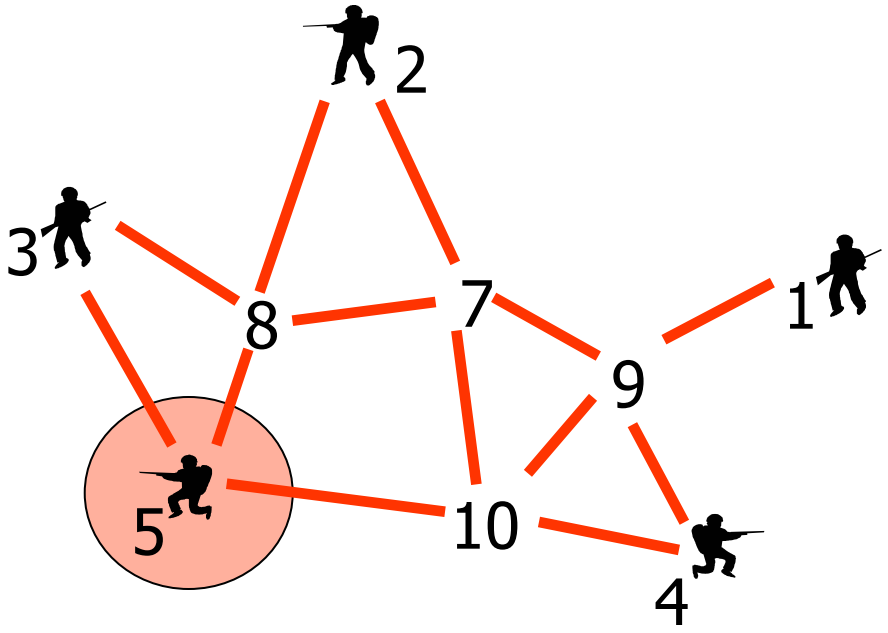
Hand Held Communications

UWB Link Data

Range	500 m
Data Rate	10 kbps
S/N@ Max Range	10 dB
Peak Power	14 dBm
Pulse Width	5 nsec
Center Frequency	300 MHz
Bandwidth	200 MHZ
Antenna Gain	2 dB
Antenna Height	2 m
System Loss	1 dB
Noise Figure	1 dB

EMI to Legacy Systems

EMI Zone	20 m
I/N	6 dB
Noise Figure	10 dB
Band Width	25 kHz
Antenna Gain	2 dB
Antenna Height	2 m
System Loss	1 dB



Implementations:
- Tactical Combat Network
- Robust Operations in Urban and Multipath
- On-the-move Unit Communications
- Precision Timing / Geo-Localization

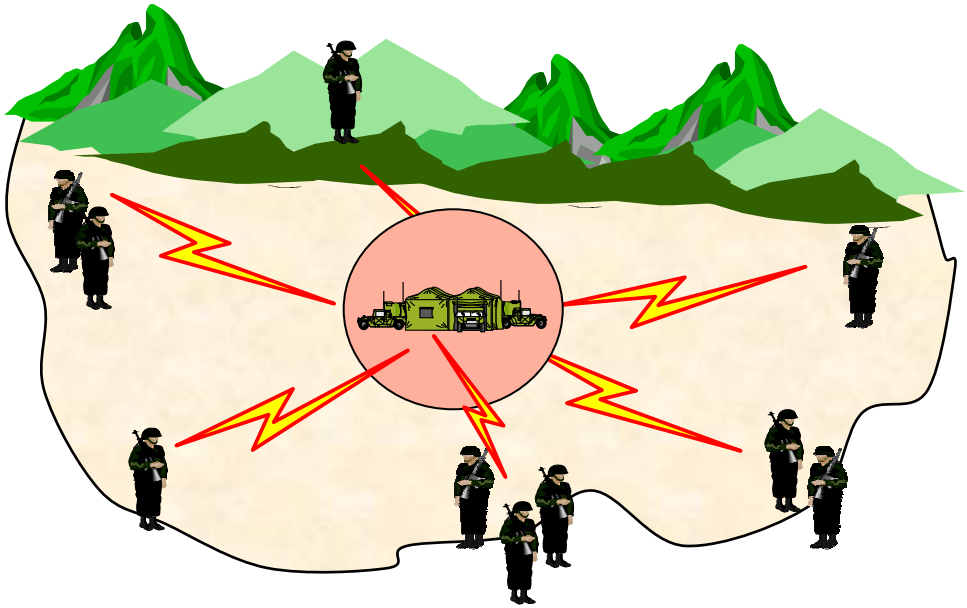
High Data Rate – Short Range

UWB Link Data

Range	100 m
Data Rate	10 Mbps
S/N@ Max Range	7 dB
Peak Power	10 dBm
Pulse Width	1 nsec
Center Frequency	6.5 GHz
Bandwidth	1 GHZ
Antenna Gain	2 dB
Antenna Height	2 m
System Loss	1 dB
Noise Figure	1 dB

EMI to Legacy Systems

EMI Zone	10 m
I/N	-9 dB
Noise Figure	5 dB
Band Width	5 MHz
Antenna Gain	-10 dB
Antenna Height	2 m
System Loss	1 dB



Implementations:
- Unit Level Integrated Operational Picture
- Video to Foxhole
- Remote Surveillance Network

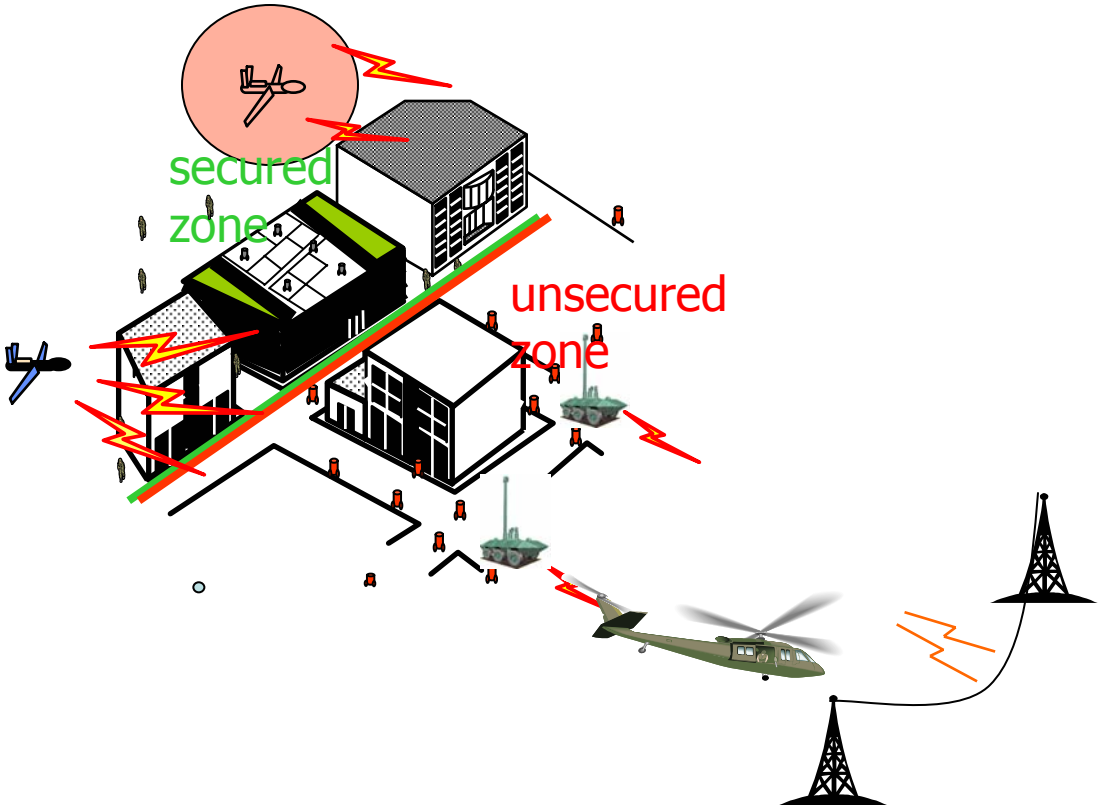
UWB Radar

UWB Radar

Range	500 m
Radar Cross Section	1 m^2
Pulse Repetition Rate	10 Kpps
S/N@ Max Range	2 dB
Peak Power	40 dBm
Pulse Width	1 nsec
Center Frequency	6.5 GHz
Bandwidth	1 GHZ
Antenna Gain	24 dB
Antenna Height	2 m
Noise Figure	1 dB
Total System Loss	2 dB

EMI to Legacy Systems

EMI Zone	10 m
I/N	-21 dB
Noise Figure	5 dBm
Band Width	5 MHz
Antenna Gain	-10 dB
Antenna Height	2 m
System Loss	1 dB



Implementations:
- High Resolution Imaging
  - Through the Wall
  - Human detection
- Micro UAV/ROV Collision Avoidance
- Wire Detection

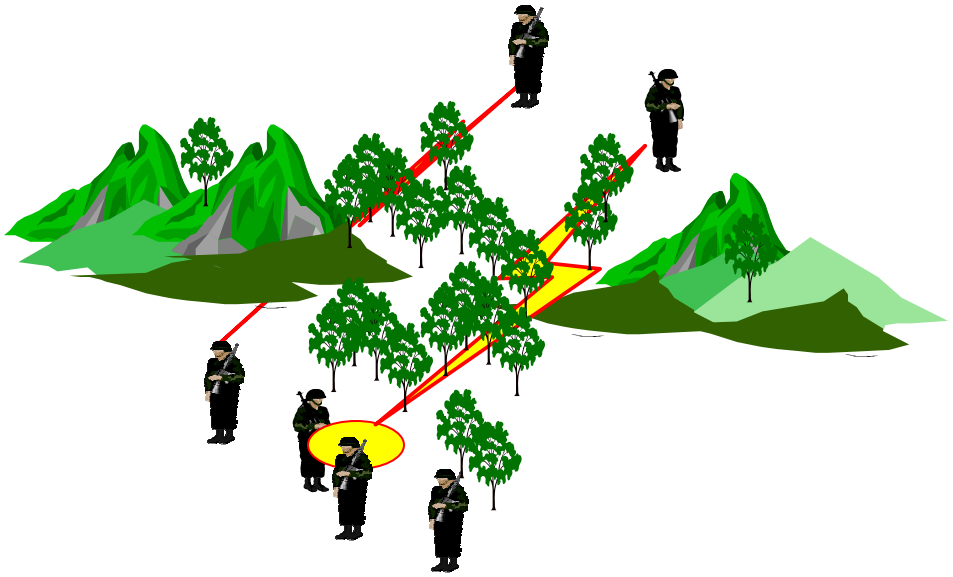
UWB Personnel Radar

UWB Radar

Range	100 m
Radar Cross Section	1 m^2
Pulse Repetition Rate	100 pps
S/N@ Max Range	6.6 dB
Peak Power	50 dBm
Pulse Width	3.3 nsec
Center Frequency	850 MHz
Bandwidth	300 MHZ
Antenna Gain	2 dB
Antenna Height	2 m
Noise Figure	1 dB
Total System Loss	1 dB

EMI to Legacy Systems

EMI Zone	10 m
I/N	20 dB
Noise Figure	5 dBm
Band Width	6 MHz
Antenna Gain	2 dB
Antenna Height	2 m
System Loss	1 dB



Implementation:
- Personnel Detection

Overall Summary of Preliminary EMI Test Results

- EMI Impact is related to the Average UWB Power in the Narrowest Receiver Passband
- For Most Conditions EMI Impact for UWB Signal is Approximately the Same as White Noise
- UWB Waveforms with Low PRFs Do Not Impact Performance
- UWB Waveforms with High PRFs Impact Performance Only When Spectral Component is at or Near Receiver Frequency
- Spectral Mask Defines UWB Susceptibility Threshold for Legacy Systems
- UWB Systems Can Support Militarily Useful Functions and Can Coexist With Legacy Systems Without Creating EMI